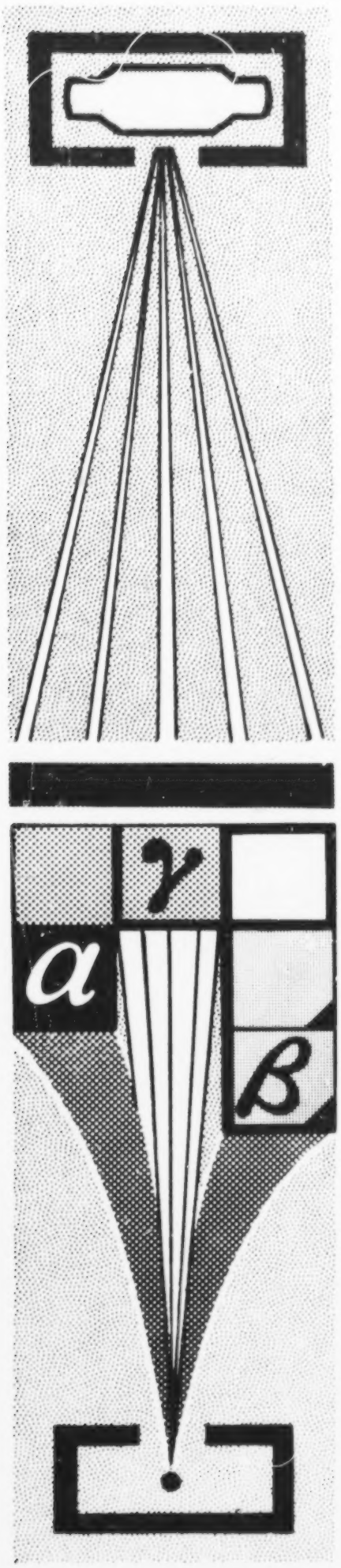

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DENTAL X-RAY TEACHING AND TRAINING REPLICA

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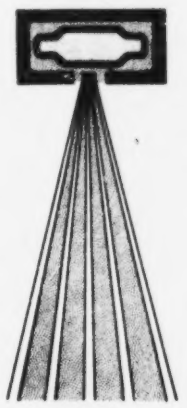
14

MORP 68-8

DENTAL X-RAY TEACHING AND TRAINING REPLICA

by

Wayne R. Jameson, D.D.S. and Ray W. Alcox, D.D.S.
X-ray Section
Medical and Occupational Radiation Program



SEPTEMBER 1968

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Environmental Control Administration
National Center for Radiological Health
Rockville, Maryland 20852

MEDICAL AND OCCUPATIONAL RADIATION PROGRAM

Technical Reports

The following technical reports issued by the Medical and Occupational Radiation Program are available through the Office of Information, National Center for Radiological Health, Public Health Service, U.S. Department of Health, Education, and Welfare, Rockville, Maryland 20852:

PHS No. 1559	Physical Survey Manual Dental X-ray
PHS No. 1582	Radiation Protection Survey Report Manual
PHS No. 1633	KWIC Index to the Journal of the Health Physics Society (1958-1966)
PHS No. 1698	Radium and the Physician
PHS No. 1831	KWIC Index to the Journal of Nuclear Medicine (1960-1967)
PHS No. 999-RH-29	Tritium Contamination in Particle Accelerator Operation
PHS No. 999-RH-30	Reduction of Radiation Exposure in Nuclear Medicine
MORP 67-1	X-ray Emission from Shunt Regulator Tubes for Color Television Receivers
MORP 67-2	Radium Disposal Project
MORP 67-3	Radium Source Integrity Testing Progress Report
MORP 67-4	Design of Interlocked Radium Shipping Container
MORP 67-5	A Summary Report on X-ray Diffraction Equipment
MORP 67-6	Georgia Radium Management Project. . . Phase II
MORP 67-7	Decontamination Study of a Family Dwelling Formerly Used for Radium Processing (Preliminary Copy)
MORP 68-1	A Collection of Radium Leak Test Articles
MORP 68-2	Recommendations for the Safe Operation of Particle Accelerators
MORP 68-3	A System for the Registration of Radiation Sources
MORP 68-4	Medical Surpak Summary Report
MORP 68-5	The Use of Radium in Consumer Products (In preparation)
MORP 68-6	Preliminary Results of 5263 X-ray Protection Surveys of Facilities with Medical X-ray Equipment (1962-1967)
MORP 68-7	A Review and Analysis of Radium Incidents
MORP 68-8	Dental X-ray Teaching and Training Replica
MORP 68-9	Development and Evaluation of an Automatic Collimator for Medical Diagnostic X-ray Machines
MORP 68-10	Survey of the Use of Radionuclides in Medicine: Preliminary Report

FOREWORD

The National Center for Radiological Health conducts a national program for the prevention and control of radiological hazards to public health through (1) surveillance activities, (2) research and development programs, (3) technical assistance to governmental and other organizations, (4) technical training programs, (5) development of criteria and codes, (6) administration of grants, (7) consultation on international programs, and (8) public information and education activities.

The Medical and Occupational Radiation Program is the component of the Center which deals with reduction of unnecessary radiation exposure of patients, workers, and others incidentally exposed by the use of X-rays, radioactive materials, radiopharmaceuticals, and particle accelerators.

The Center publishes its findings in Radiological Health Data and Reports (a monthly publication), the Environmental Health Series, Public Health Service numbered reports, appropriate scientific journals, and Program and Branch technical reports.

The technical reports of the Medical and Occupational Radiation Program (MORP) allow comprehensive and rapid reporting of the results of inhouse and contractor projects. The reports are distributed to State and local radiological health program personnel, Center technical staff, Center advisory committee members, University radiation safety officers, libraries and information services, industry, hospitals, laboratories, schools, the press, and other interested individuals. These reports are included in the collections of the Library of Congress and the Clearinghouse for Federal Scientific and Technical Information.

I encourage the readers of these reports to inform the Center of any omissions or errors. Your additional comments or requests for further information are also solicited.

James G. Terrill, Jr.
Center Director

PREFACE

This report describes the development of a "Dental X-ray Teaching and Training Replica" designed to serve as a substitute for human subjects in the study of oral roentgenology. The prototype phantom was constructed by the Alderson Company, Stamford, Connecticut, under contract with the National Center for Radiological Health. The use of such manikins in schools of dentistry, dental hygiene, and schools for training dental assistants should do much to eliminate needless radiation exposure and improve training in roentgenographic techniques.

John C. Villforth
Chief, Medical and Occupational
Radiation Program

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INTRODUCTION

In teaching oral roentgenology, many schools which train dentists, dental hygienists, and dental assistants use fellow students and other individuals as practice patients since no adequate substitute for a live subject is available. Not all these practice films are interpreted for their clinical value. Many are retakes resulting from inexperience. Those films not used for diagnostic purposes result in unnecessary exposure to ionizing radiation. The possible extent of such unnecessary exposure is indicated by the number of dentists and technicians trained each year. In 1965, 3,181 dentists, 1,491 dental hygienists, and 1,241 dental assistants were graduated (1). Scientific Committee No. 16 of the National Council on Radiation Protection and Measurement is considering the efficacy of this practice and will publish their recommendations in NCRP Report No. 35.

A manikin instead of a live patient in dental X-ray training could eliminate this unnecessary X-ray exposure. A manikin would have additional assets as a teaching and training device: multiple exposures can be taken to perfect the students' technique; the effects on film quality of variations in technical factors or techniques can be demonstrated; dosimetry can be used with the manikin to demonstrate methods of dose reduction; student performance can be better assessed, since the "subject" is a constant factor; X-ray facilities can be more efficiently utilized since the "subject" is always available; and the elimination of live subjects for training will emphasize the importance of radiation protection. In addition, teaching institutions could have several manikins with differing pathology to provide a greater range of practical experience for students.

The X-ray Section of the Medical and Occupational Radiation Program, National Center for Radiological Health, has developed a manikin of a human head, named DXTTR (Dental X-ray Teaching and Training Replica), to serve these functions. This report describes the development and clinical evaluation of the first and second prototypes (DXTTR-I and DXTTR-II). Additional clinical evaluation of DXTTR-II is being performed and will be reported in a later document.

HISTORY

The idea of DXTTR originated at a meeting of consultants to the Dental X-ray Program of the Division of Radiological Health (now the National Center for Radiological Health) in December 1962. One of the consultants, Dr. Theodore Grant, then Assistant Professor of Dental Radiology at the University of California Dental School, stated in a letter after the meeting that he had always wanted a suitable patient substitute--or manikin--for teaching dental X-ray technique.

Although a project was established in 1963, the manikin remained just an idea until a contract was awarded in May 1965 to Alderson Research Laboratories, Inc., to design and manufacture the first manikin. The prototype, DXTTR-I, was delivered in August 1965 and was demonstrated at the Thirteenth Annual Oral Roentgenology Workshop at Seattle, Washington, in August 1965. As a result of the interest shown and the many suggestions for improvements, the manikin was returned to Alderson Research Laboratories for improvements and modifications. The improved manikin was completed in October 1965 and demonstrated the next month at the American Academy of Oral Roentgenology meeting in Las Vegas. It was well received. The Dental X-ray Program then purchased six additional manikins from Alderson Research Laboratories for evaluation by institutions that teach oral roentgenology. These were tested during the 1966-67 academic year at the dentistry schools of the Universities of Michigan, Nebraska, and California and at Laney College in Oakland, California.

As a result of the clinical evaluation of DXTTR-I, a new prototype, DXTTR-II, was developed and accepted for testing in December 1967.

DXTTR-I

Specifications

Public Health Service Contract No. PH 86-65-82 specified the following design and construction of DXTTR-I:

The manikin will include an average-sized head mounted on a locking-type adjustable support. The support will be adaptable to a dental chair and will enable positioning of the head in the various positions normally employed in oral roentgenology. Also included in the assembly will be two adjustable locking-type arms capable of applying pressure to hold X-ray films in selected positions during exposure of the film.

The head of the manikin will include the essential parts of a human skull necessary to provide natural teeth and bones in the areas normally exposed during dental radiography. The movement of the mandible will approximate the natural vertical movement of the human jaw and will be controlled externally, with provisions for locking in position when the user has established the desired jaw location and pressure. The materials used to construct the areas normally exposed in dental radiography will be radio-equivalent to the human tissues in those areas. The oral cavity will approximate the human anatomy as closely as possible, including mobility of tongue and flexibility of cheeks, lips, and similar soft tissues normally exposed in dental radiography.

Design

The design of DXTTR-I, as delivered to the schools for evaluation, was as follows: (Figure 1)

The maxilla and mandible were sectioned from a human skull and incorporated in a metallic skull. A hand-operated lever through the top of the head was used to open and close the mandible for insertion and removal of films. A foot-operated switch actuated solenoids to hold the jaw in place after positioning. The "skin" was a tough, relatively inelastic material. The cheeks and tongue were hollow and could be filled with water by the user to provide tissue equivalence. The facial "skin" was removable to enable viewing of the maxilla and mandible. The neck joint was such that the head could only move in a forward and backward direction. Two "arms" and "fingers" were provided for film holding. The entire manikin was attached to the dental chair with four U-clamps.

Clinical Evaluation

After using DXTTR-I, the teaching institutions had the following comments:

The manikin was difficult to assemble, mount on the dental chair, and disassemble because of its weight (~40 pounds) and the complexity of its design. Also, it was too large for convenient storage when packed in its case. The head should be mounted on a swivel joint and include a means for restraining it from falling forward. Arms and fingers were too complicated, making them difficult to adjust. A single arm and finger of simplified design would suffice. The foot switch and solenoid mechanism for holding the jaw in place after positioning were not satisfactory because frequent short circuits occurred. The facepiece was difficult to remove and replace. The mouth did not open widely enough. The "skin" was not sufficiently flexible to permit retracting the cheeks. The water chambers for tissue equivalence developed leaks and were determined not to be a critical need. Tongue construction was not lifelike. Because the floor of the mouth was too inflexible and the palate was not sufficiently vaulted, the oral cavity was not representative of patients normally encountered and did not permit ready insertion and removal of films.

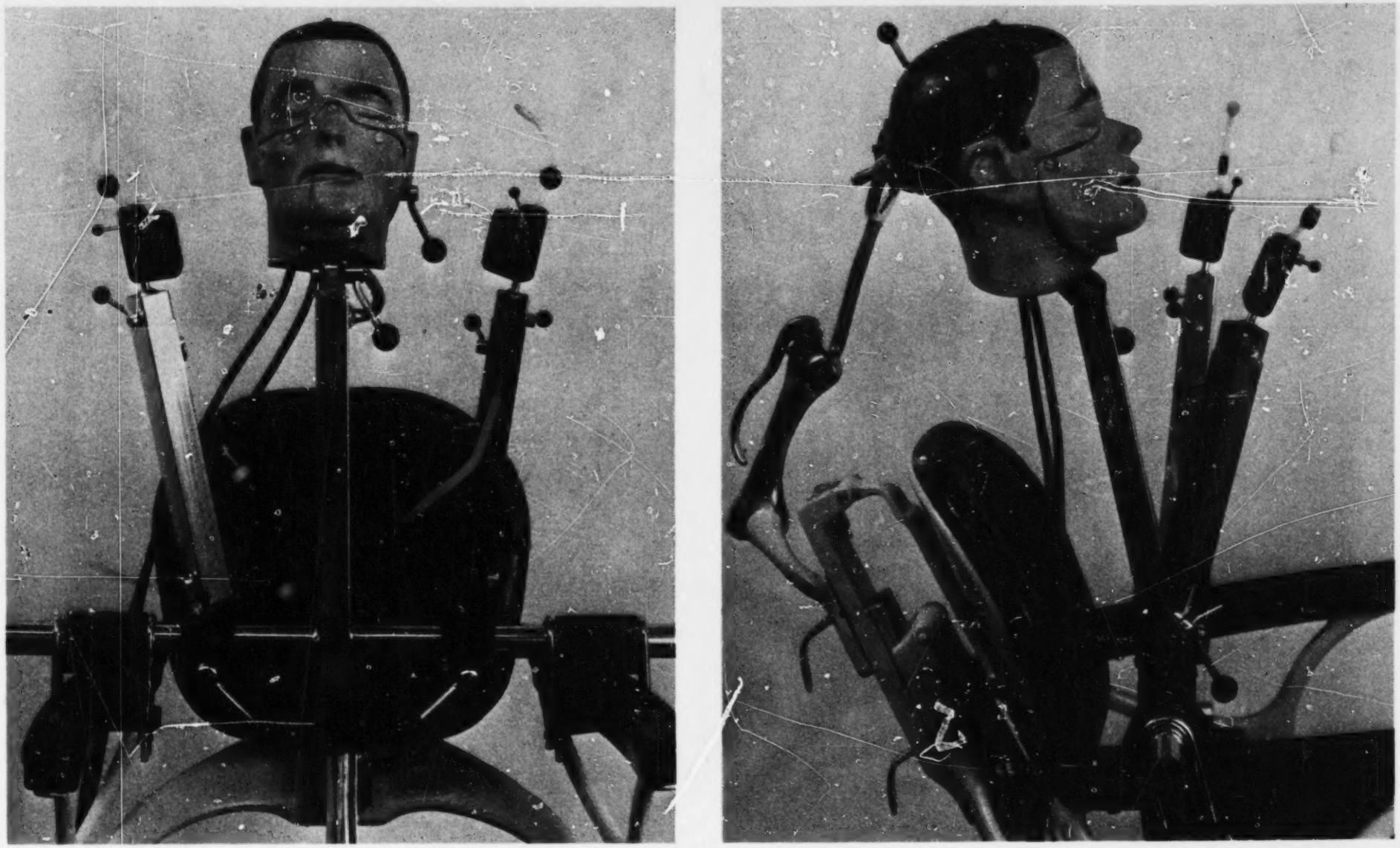

Figure 1. Front and side views of DXTTR-I. Note the removable face plate, two arms with multiple-joint fingers to hold films, and method for attaching to dental chair. DXTTR-II is shown in figure 2.

DXTTR-II

Design

As a result of the clinical evaluations of DXTTR-I, the X-ray Section developed a new set of specifications incorporating the suggested changes. A prototype was then built to these specifications under Public Health Service Contract No. PH 86-67-131 by Alderson Research Laboratories. This manikin, called DXTTR-II, was accepted by the X-ray Section in December 1967. It is much lighter (~11 pounds), smaller, simpler to operate, and more closely approximates human subjects. Photographs of DXTTR-II appear in figure 2.

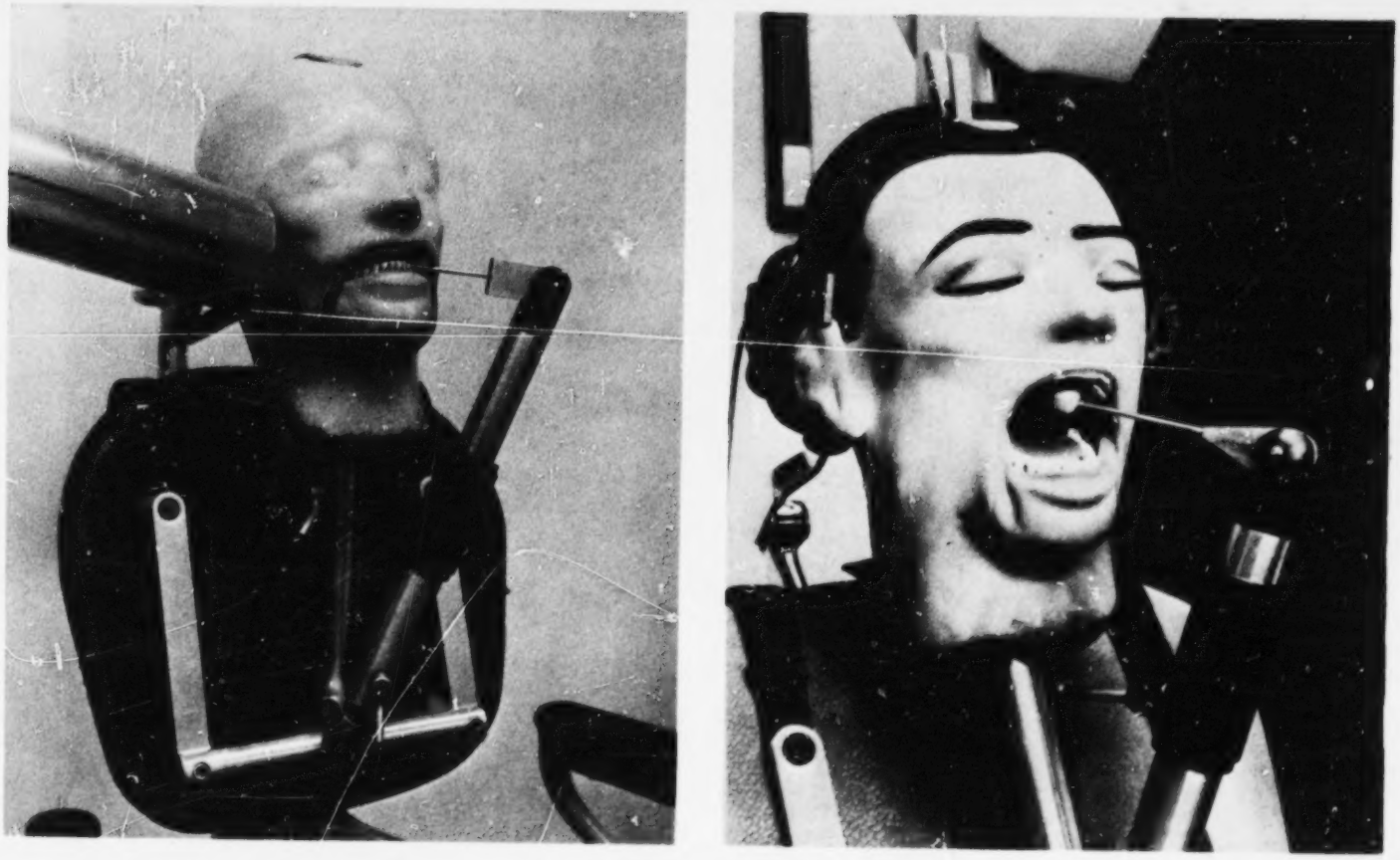

Figure 2. DXTTR-II. Note single arm for holding film, simplified method for mounting on dental chair, and the closed and open mouth positions. The right photo has been retouched to show facial features and hair.

Internal construction is shown in a lateral radiograph, figure 3. A description follows:

Universal angulation of the head is provided by a ball joint in the neck. After positioning, this is locked by a lever. A single "arm" and "finger" are provided. Arm length, arm angle, and finger angle are easily adjusted to hold films in any position within the mouth as the patient may do for certain dental radiographic techniques. The entire head, neck, and arm assembly pivots forward and back and is secured by a rubber strap on the head which fastens around the head rest on the chair. This assembly is suspended from the chair back by a pair of hooks (two sets are provided to allow for extremes of chair-back thickness).

The jaws are opened and closed by an operating lever which projects through the skull cap; an internal ratchet mechanism then locks the jaws in the desired position. The mouth will close by spring action when the ratchet is released. This can be done with a release button on the operating lever or a foot pedal connected to the head by a cable.

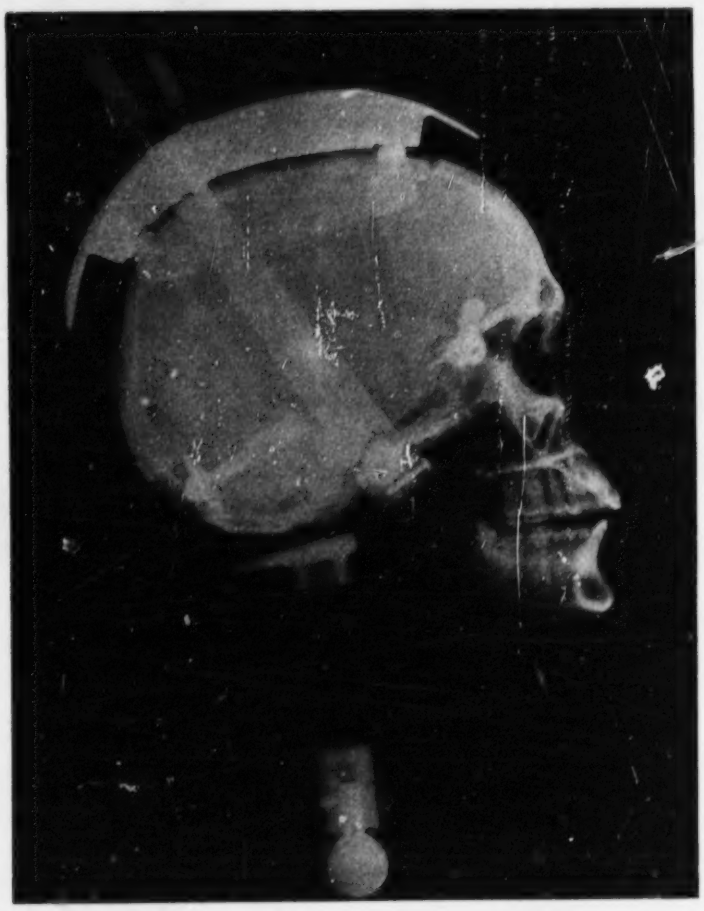

Figure 3. Radiograph of DXTTR-II showing internal construction.

The manikin head utilizes a human skull specimen carefully selected to provide a full complement of sound teeth in good occlusion and a palatal contour of sufficient height for normal film positioning. The cranial cavity is filled with a tissue-equivalent rubber which strengthens the dried bone. A section of this material is also used in the floor of the mouth to provide mechanical stability under the chin when the mouth is opened. The skull is covered with a molded latex "skin" over polyurethane foam "flesh." This covering is in two sections to provide adequate flexibility of the cheeks. The tongue is made of foam rubber covered with latex.

Clinical Evaluation

DXTTR-II was clinically evaluated at Howard University Dental School during January and February 1968. Dr. Coleman Reed Tuckson, Jr., Head, Department of Roentgenology, stated, "My staff and I are happy to endorse and recommend its universal application as an extremely useful aid in the teaching of dental radiographic techniques." DXTTR-II was demonstrated to oral roentgenologists during the Oral Roentgenology Research Conference at the University of Illinois in February 1968. The oral roentgenologists who examined DXTTR-II at the Conference, most of whom had worked with DXTTR-I, were quite favorably impressed. Additional clinical evaluations are being performed and will be reported later.

DISCUSSION

There are 49 dental schools, 58 dental hygiene schools, and 64 dental assisting schools accredited by the American Dental Association, as well as a great number of dental assistant programs that are not accredited, in the United States (1). Each school could probably use from one to five manikins, depending on the number of students and the school budget.

The Public Health Service has applied for a patent, and manufacturers are being encouraged to produce manikins in quantity to meet the projected demand. A purchase cost has been estimated at less than $1,000.

SUMMARY

In many dental schools, students and other personnel have been needlessly exposed to radiation because an adequate substitute for the human patient was not available for use in oral roentgenology classes. Personnel, therefore, practiced on each other to learn proper X-ray techniques.

Several years ago, the National Center for Radiological Health set out to remedy the situation. They developed a manikin, named DXTTR-I (Dental X-ray Teaching and Training Replica), to replace human practice subjects. This model was tested and evaluated at four schools. After using it a year, the schools found various flaws and deficiencies and made other suggestions for its improvement. These have now been incorporated into a new prototype, DXTTR-II. Oral roentgenologists who have examined and used this new model have been very favorably impressed.

The manikin consists basically of a selected human skull with polyurethane foam "flesh" and latex "skin," as well as a tongue of the same materials. A mechanical arm and finger are provided to hold dental films. The entire assembly hooks over the back of a dental chair (or other chair) and has a mandible that can be opened, closed, or locked in any position.

Use of this manikin will improve dental X-ray teaching programs, not only by eliminating the present exposure to humans but also by making possible unlimited radiography of a standard subject for perfecting technique and for experimentation.

REFERENCE

(1) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR HEALTH STATISTICS. Health resources statistics. PHS Publication No. 1509, . pp. 44-45 (1965), Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402.

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